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An Automated Combined Microwave and Electric-Element Fish Dryer

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ABSTRACT

This work provides an improvement in the efficiency and economics of the drying process by combining an electric hot air flow and microwave drying unit. It is intended to improve the nutritional qualities for the dried fish market and its shelf life. We fabricated a drying Kiln having combined 1.6KW twin microwave gun and 4KW quad electric element, volume 897,000cm^3 and wet fish cargo capacity up to 80Kg. The characteristics of electric drying (ED) and combined microwave-electric drying (MED) of *Clarias Gariepinus* tissues were studied experimentally. Results show that the moisture ratio decreases with an increase in microwave drying time when microwave power is fixed. The drying rate is fast initially and then falls slowly. Finally, the curve of MED was steeper than that of ED alone during the initial drying period. The data of the percentage of water and volatile oil loss by drying with respect to time follows a logarithmic relationship. The taste panels evaluations and sample results of organoleptic assessment of the dried *Clarias Gariepinus* was found to range from excellent quality for appearance, taste and odour, good quality for fragmentation and texture. The addition of microwave to the electric heater has saved about 28 hours in drying time and reduced the product cost by energy consumption to 38%. In conclusion this method provides rapid dehydration (shorter drying time), improved product quality and flexibility in drying a wide variety of products.

KEYWORDS: Microwave Electric Drying, Internal Moisture, Nutritional Qualities

I. INTRODUCTION

There is enormous waste through spoilage of both fresh and dried fish. Preservation of fish therefore generally slows down spoilage. Preservation methods are applied with an intention to making the fish safer and extend its shelf-life [1], [2]. Drying is a complex process that causes physical, chemical and bio-chemical changes in fish products. Hence there is no guarantee on the appearance and taste of dried fish products. The method of drying and drying condition determines the qualities and shelf life for preservation and export standards In Nigeria the quality of the taste of dried fish sold in the markets vary widely since there are no quality standards for the products. Productions are done using local methods which are neither hygienic nor standardized. Presently there is lack of information in the literature about change in quality in the taste of fish after drying and such information is necessary for the development of standards and for quality control purpose. Drying is a mass transfer process resulting in the removal of water or moisture by evaporation. To achieve this, there must be a source of heat. This work utilizes the conventional electric heater combined with the microwave dryer as the source of heat.

II. MATERIALS

A combined electric hot air flow and microwave drying unit was designed to have the following parameters; Combined 1.6kW twin microwave gun, 4kW quad electric element. The oven cavity has a total volume equal to 897,000cm^3 and can contain wet fish cargo capacity of 80kg at once. The guns and heaters are automatically controlled with microcontrollers. The microwave generated by the Magnetron is focused with a WR-340 D-Band rectangular waveguide and a pyramidal aperture horn antenna (figure 1). The waveguide operates at 2.45GHz frequency [20 percent higher than cut-off frequency] propagation in TE_{10} mode.

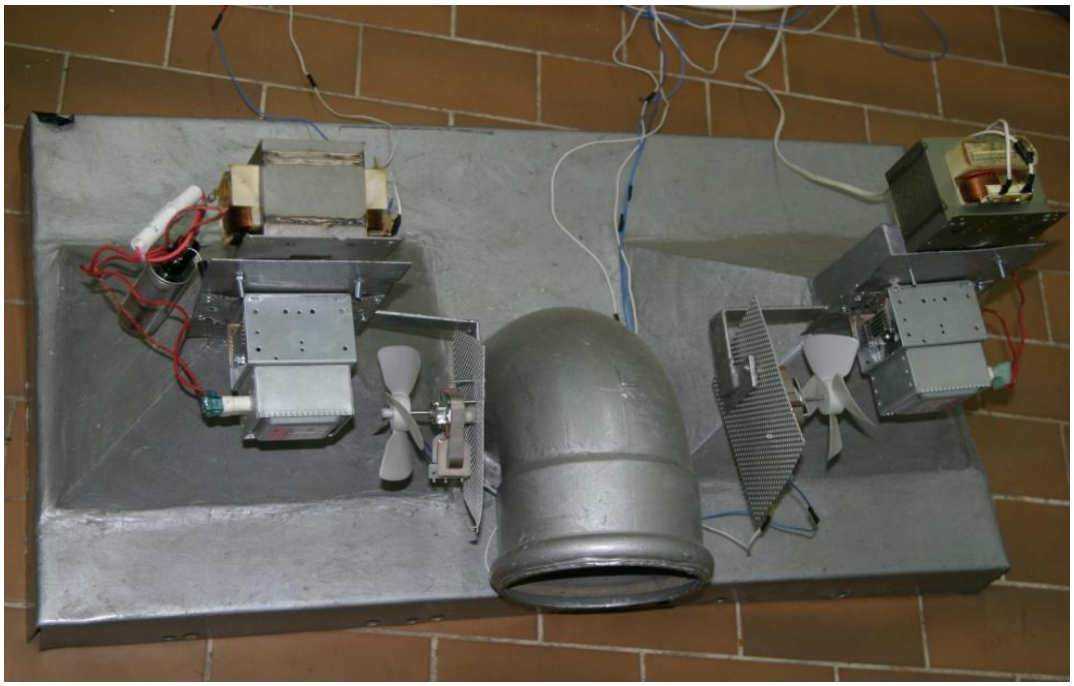

Figure 1: The twin microwave guns with Magnetrons and cooling fans.

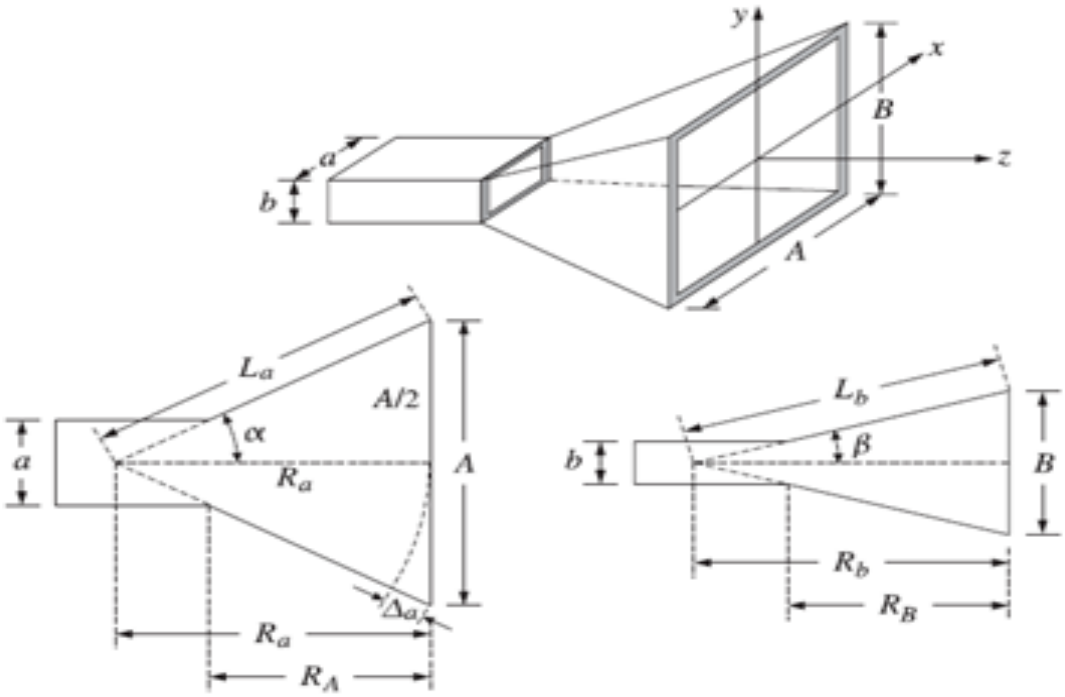

Figure 2: Geometry of the Pyramidal Horn Antenna.

III. METHODS

The geometry of pyramidal horn in figure 1 is shown in figure 2 and is related by the following expressions.

$$G = e\frac{4\pi}{\lambda^2}A.B$$

Where, G=directivity; e=aperture efficiency; A, B=dimensions of the face of horn.
For optimum directivity [3], standard horn radiator parameters are;
The aperture efficiency, e=0.49;
a=1.2593; b=1.0246;

$$2a = \frac{A^2}{2\Delta R_a} \qquad 2b = \frac{B^2}{2\Delta R_b}$$

Given the constraints of the available space and other factors, we obtained the following as the suitable radiator dimensions;

a=86.36mm; b=43.18mm; A=300mm; B=228.69mm; Directivity =14.53dB.

The pyramidal horn antenna was adopted to increase the directivity [4] of microwave (figure 3).

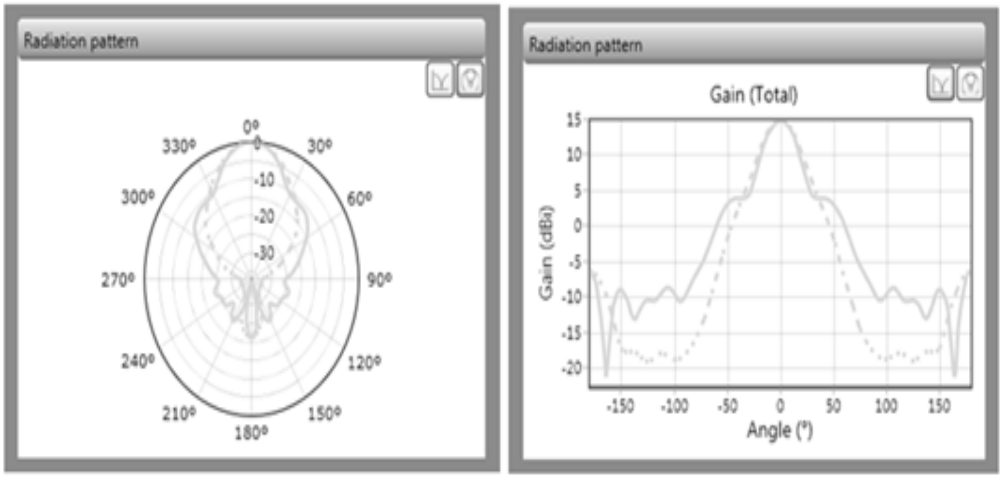

Figure 3: Radiation Pattern plot for the horn antenna.

After drying the fish, the samples were tasted by a trained panel of (10) ten people. The panel assess the color of the fish, taste, fragmentation, texture, odor and flavor and general appearance of the fish on (5) five points hedonic scale. Individual closets were used by each panelist in order to eradicate distraction and thwart communication among panelists. Sensory evaluation score cards were distributed among the panelists. Data were subjected to One-way Analysis of Variances (ANOVA), and their significant differences were indicated, means were tested using least significant differences (LSD) at 5% level of significance.

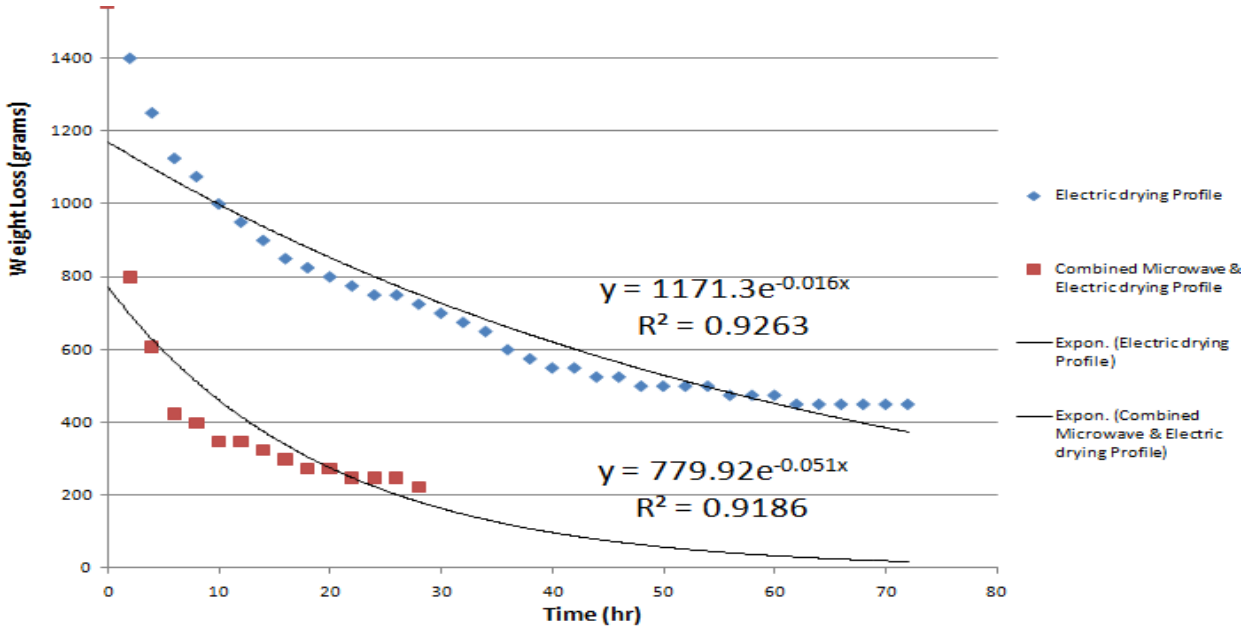

Figure 4: A comparison between only electric drying and a combined microwave and electric drying profile.

IV. RESULTS

Moisture ratio decreases with an increase in microwave drying time when microwave power is fixed. Drying rate is fast initially and then falls slowly (figure 4). Curve of microwave electric heating is steeper than that of electric heating alone. Data of percentage water and oil loss follows an exponential relationship. Microwave heating increases rate of moisture transfer towards surface significantly when compared with electric heater. Method provides rapid dehydration, improved product quality and flexibility in drying a wide variety of products.The taste panels evaluations and sample results of organoleptic assessment of the dried *Clarias Gariepinus* was found to range from excellent quality for appearance, taste and odour, good quality for fragmentation and texture. The addition of microwave to the electric heater has saved about 28 hours in drying time and reduced the product cost by energy consumption to 38%.

V. DISCUSSION

It was observed that the electric heater was relatively efficient at removing free water near the surface whereas the internal moisture takes time to move to the surface. It was evident that the mechanism of microwave heating resulted in internal vapor regeneration which led to development of a positive vapor pressure gradient that increases the rate of moisture transfer towards the surface significantly when compared with the electric heater.

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